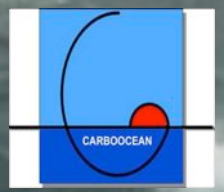
What can surface fCO_2 measurements tell us about the evolution of the Southern Ocean CO_2 sink?

Nicolas Metzl and Andrew Lenton

LOCEAN/IPSL, CNRS-UMPC

Metzl, N. (2008) Decadal increase of oceanic carbon dioxide in Southern Indian Ocean surface waters (1991-2007), *Deep Sea Research*, *SOCOVV Special Volume*

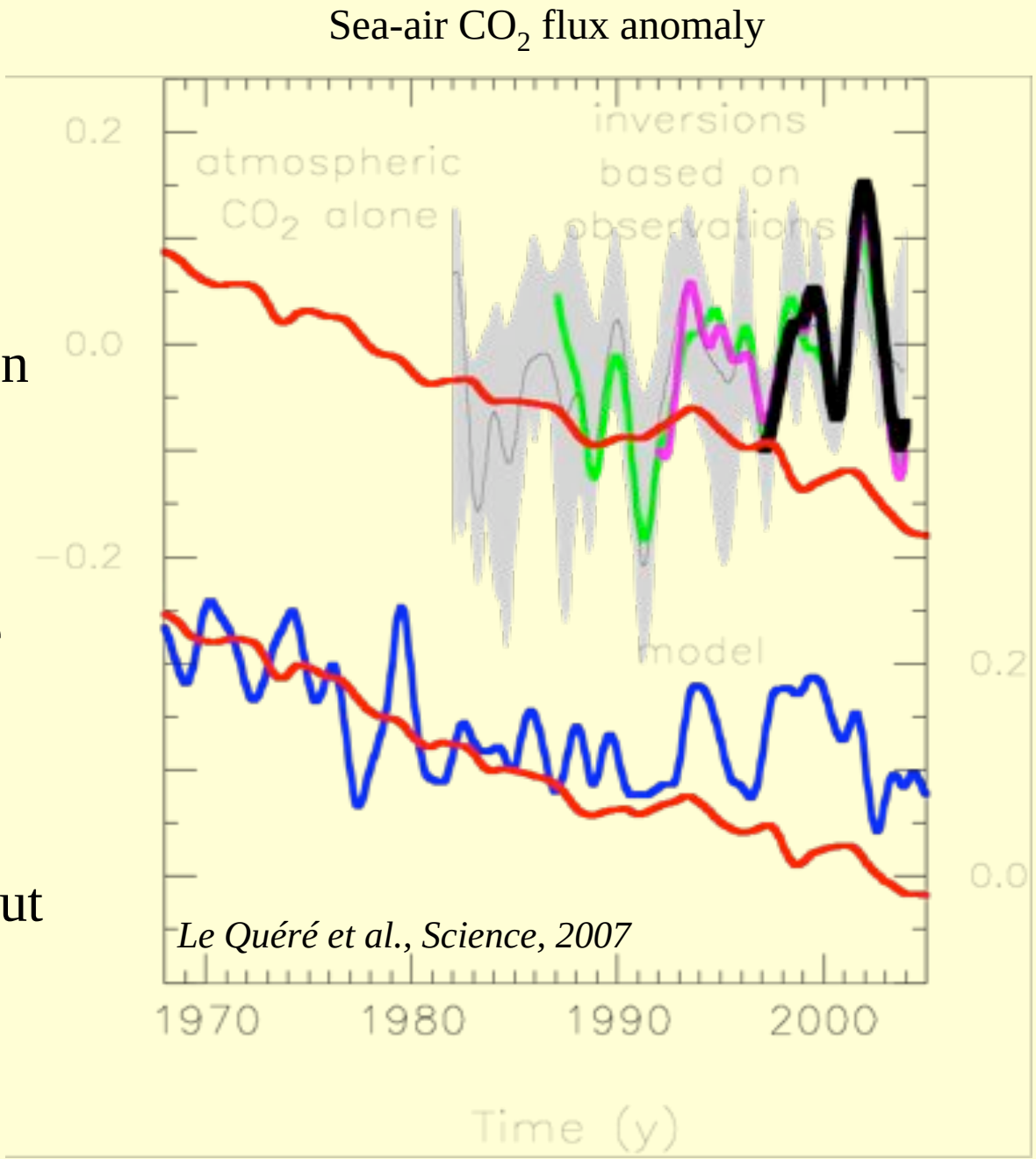


Background

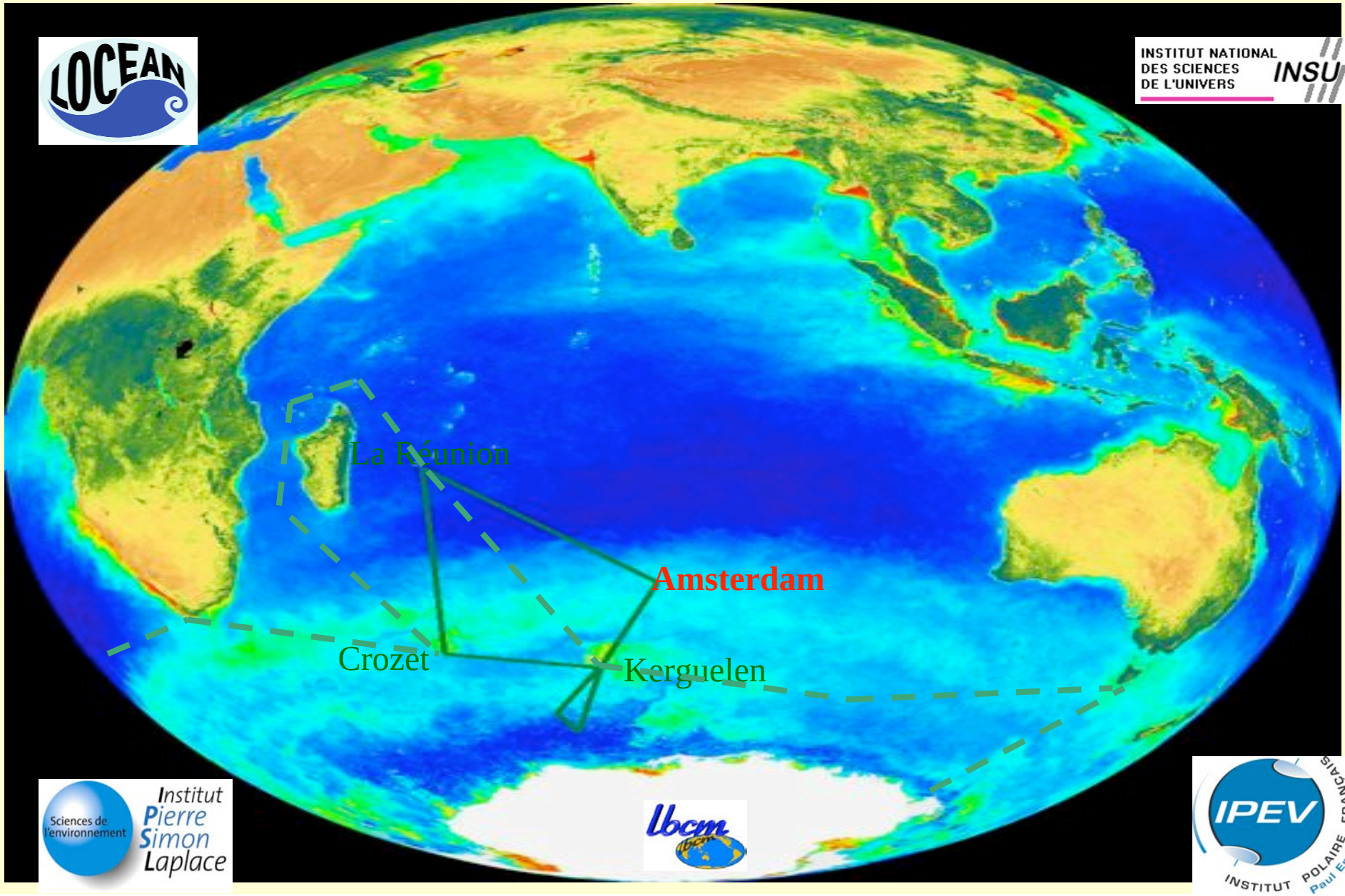
Atmospheric CO2 data and ocean model suggest a reduction of the total southern ocean carbon sink since 1980.

Changes associated with wind speed change in the Southern hemisphere

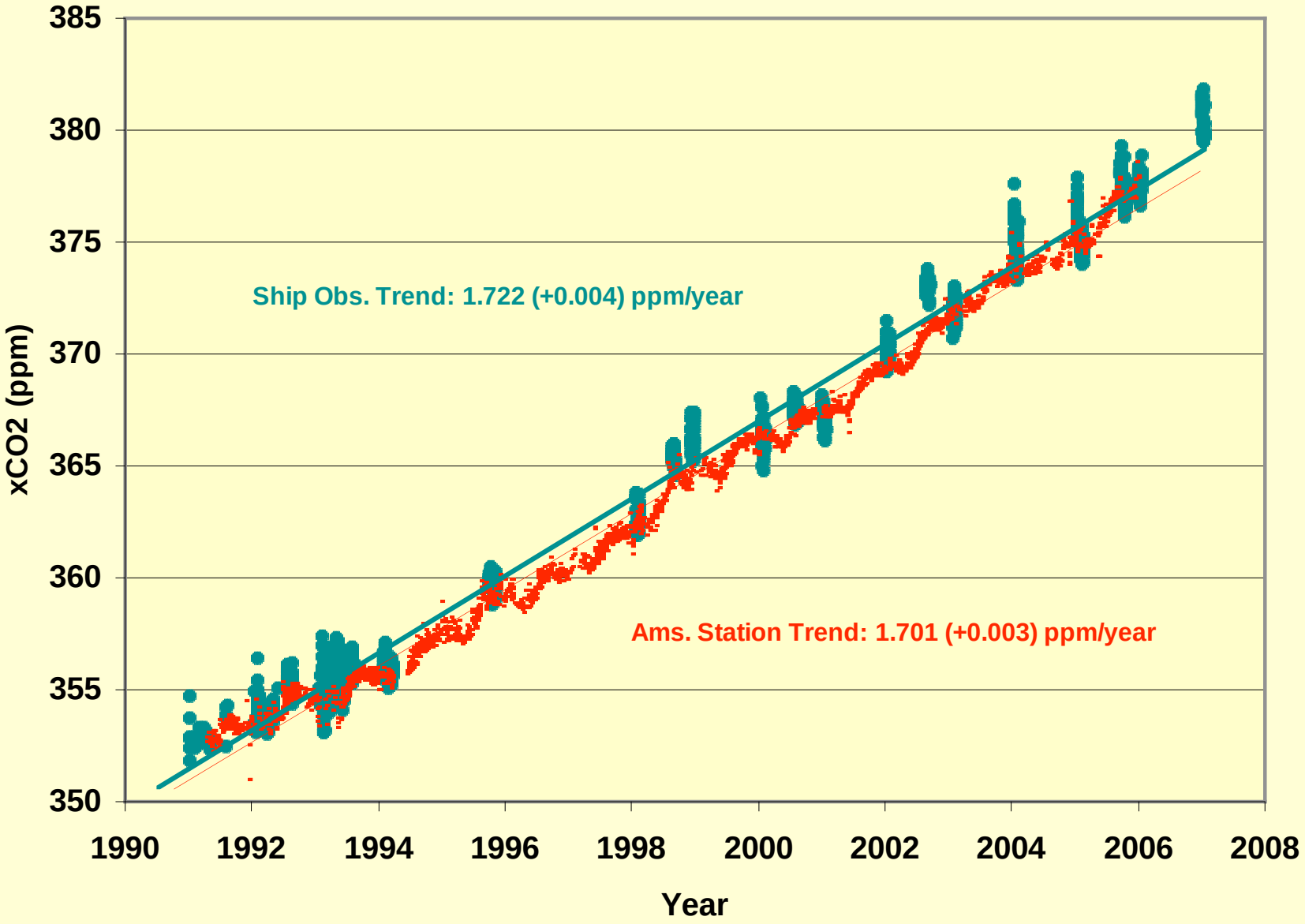
What can oceanic fCO2 measurements tell us about this evolution?

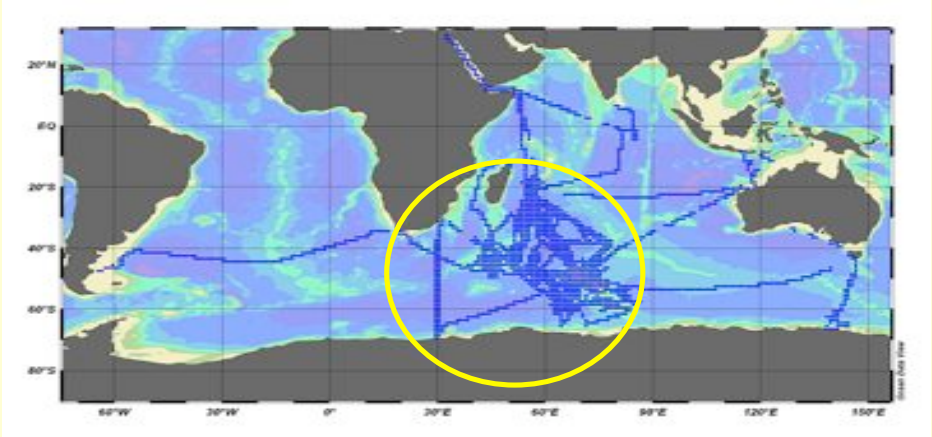


Southern and Indian Oceans
OISO cruises onboard R.V. Marion-Dufresne



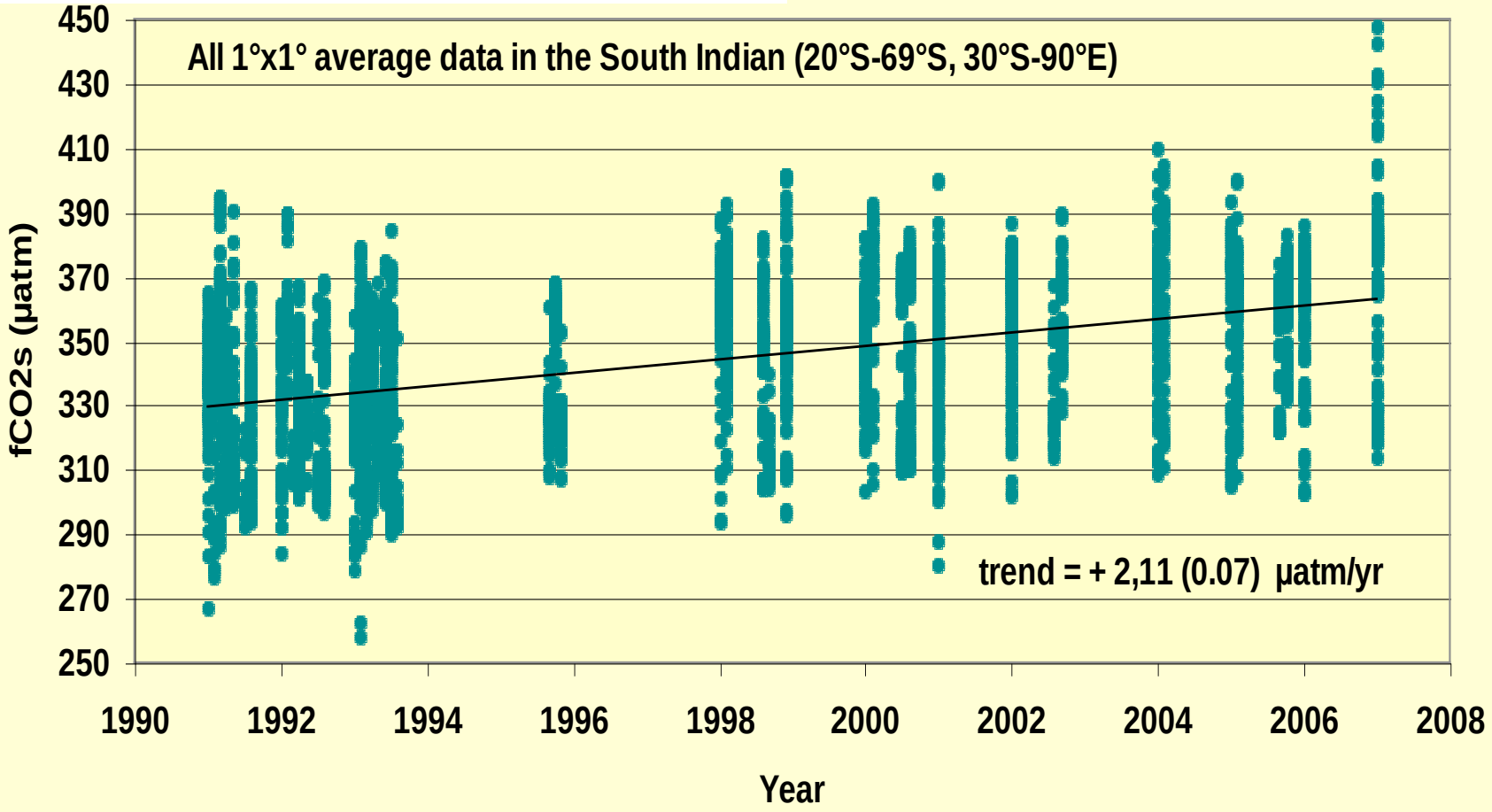
Atmospheric CO_2 Ship and Amsterdam Island



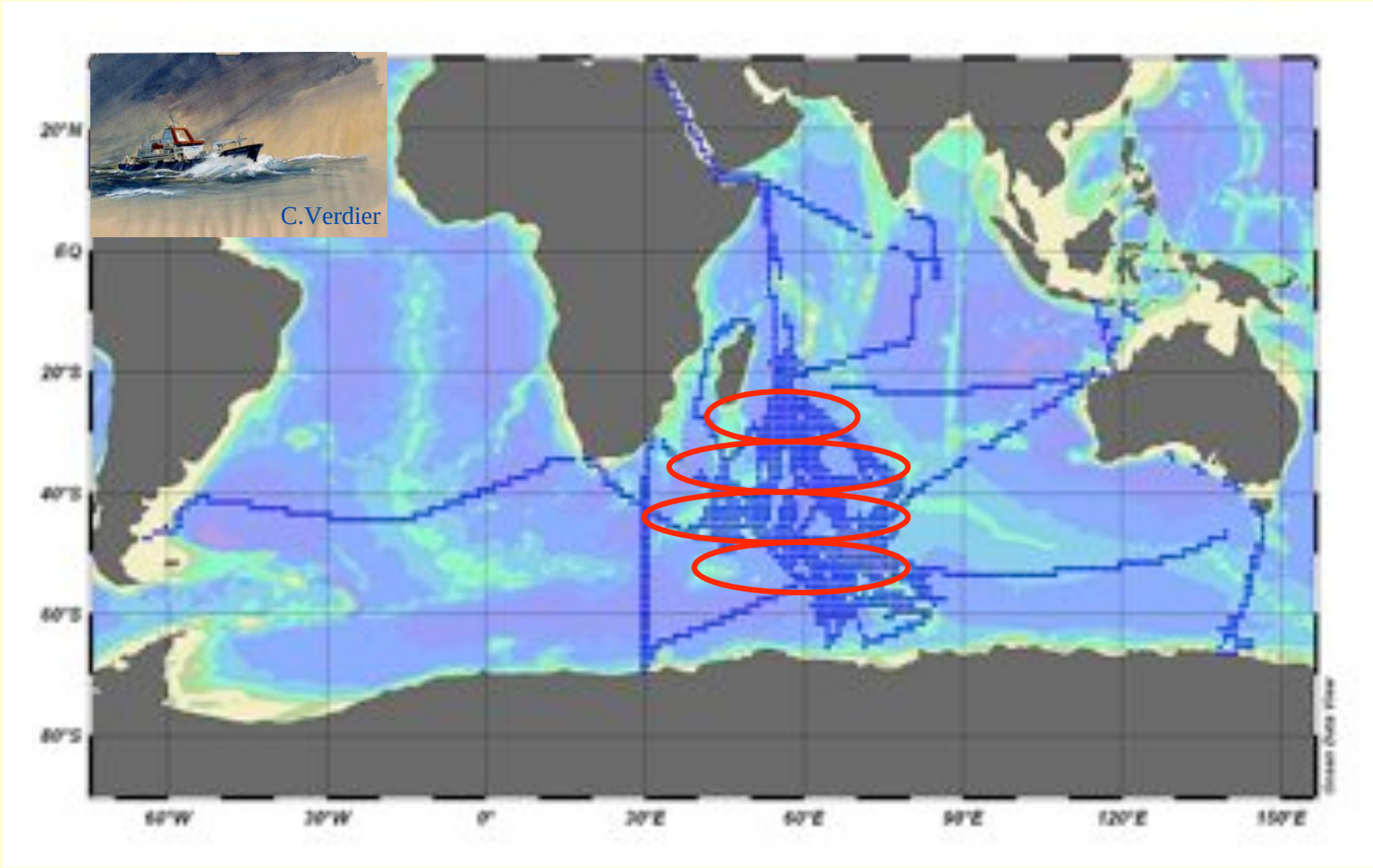


A « big-box » view

Trend atmosphere: + 1.7 µatm/yr
Trend ocean: + 2.1 µatm/yr



Cruises: 1991-1995 (*MINERVE*) and 1998-2007 (*OISO*)

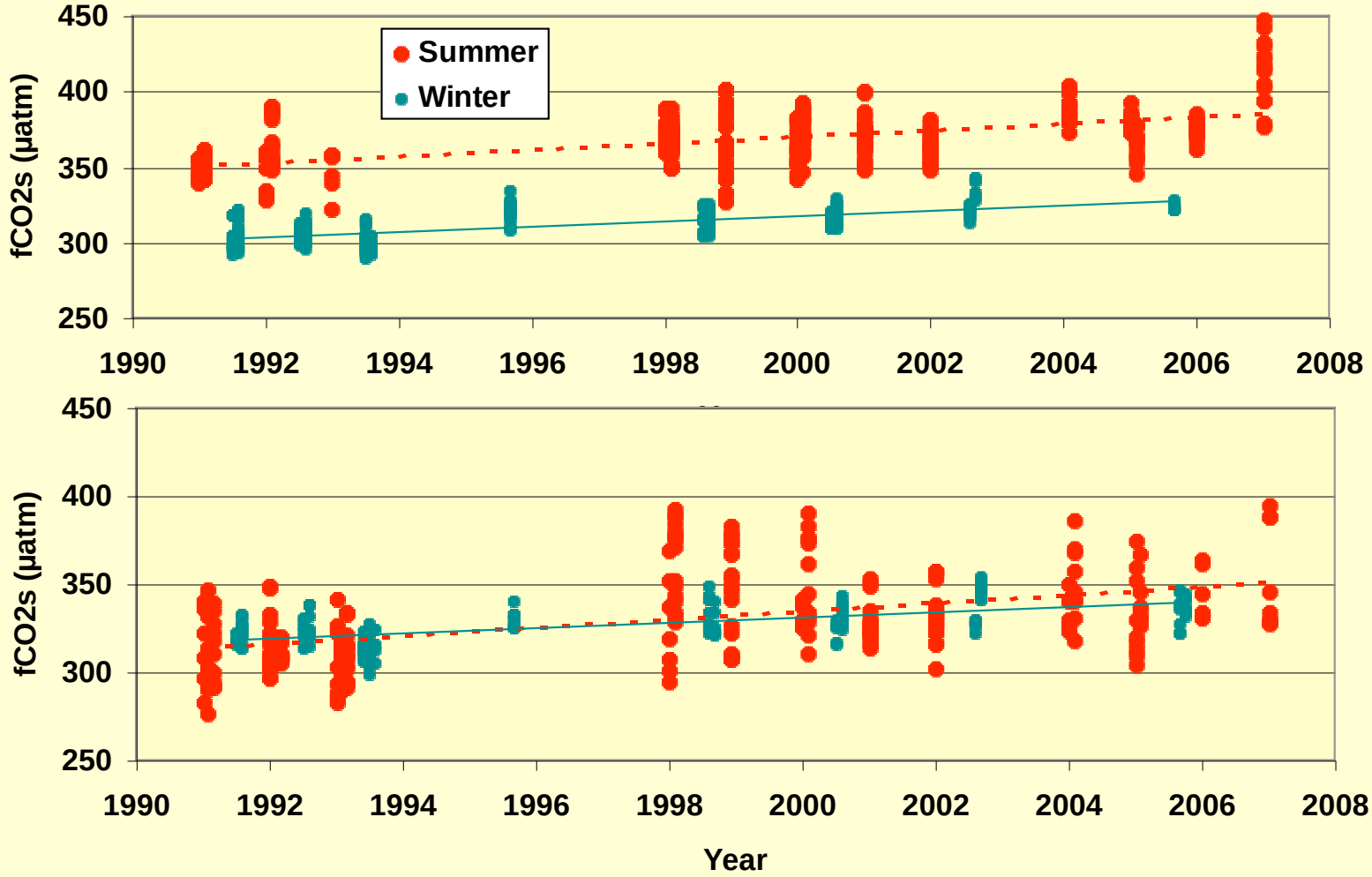


South-Western Indian sector, south of 20°S

Summer and winter ocean fCO2 (South-Indian, 1991-2007)

20-35°S

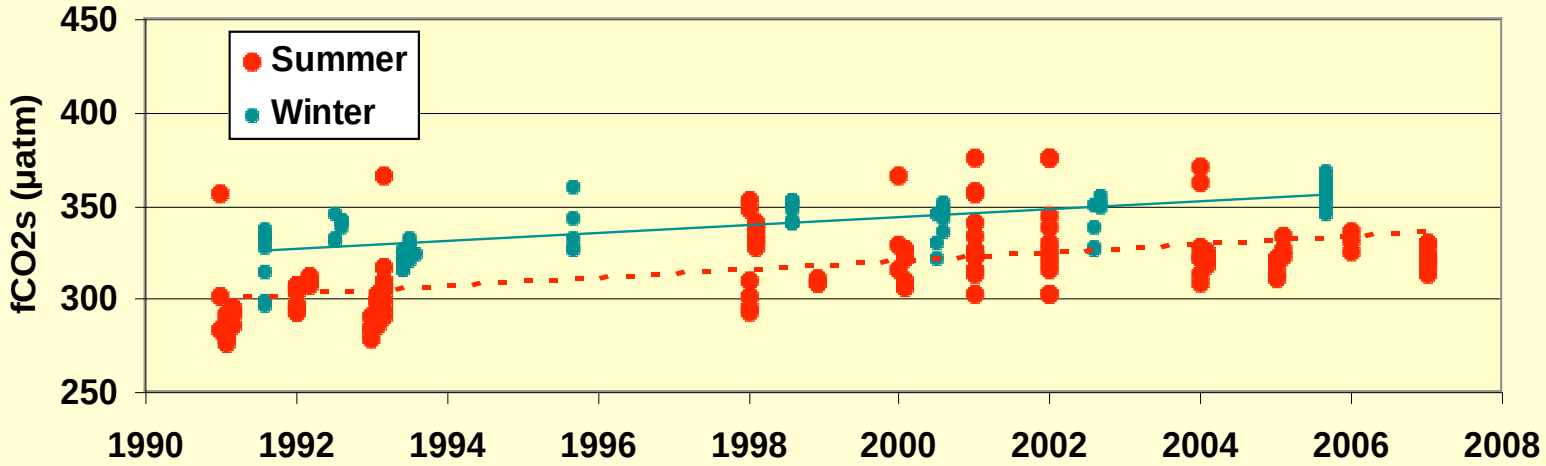
35-40°S



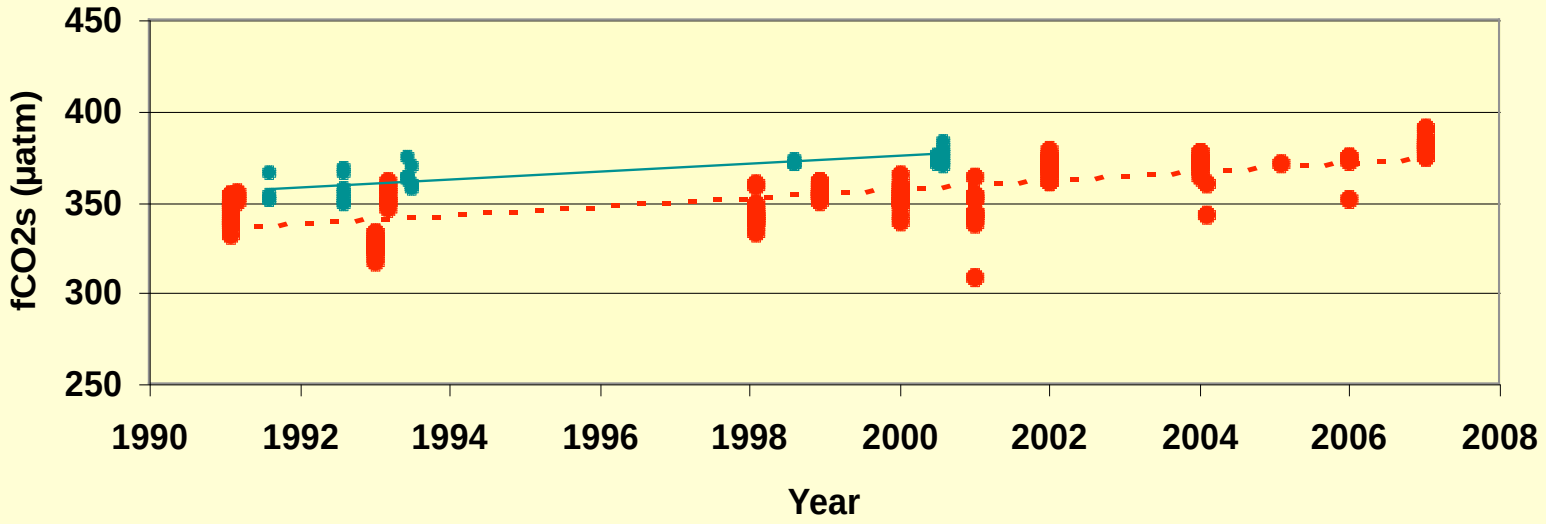
fCO2 always increases

Summer and winter ocean fCO2 (South-Indian, 1991-2007)

40-42°S

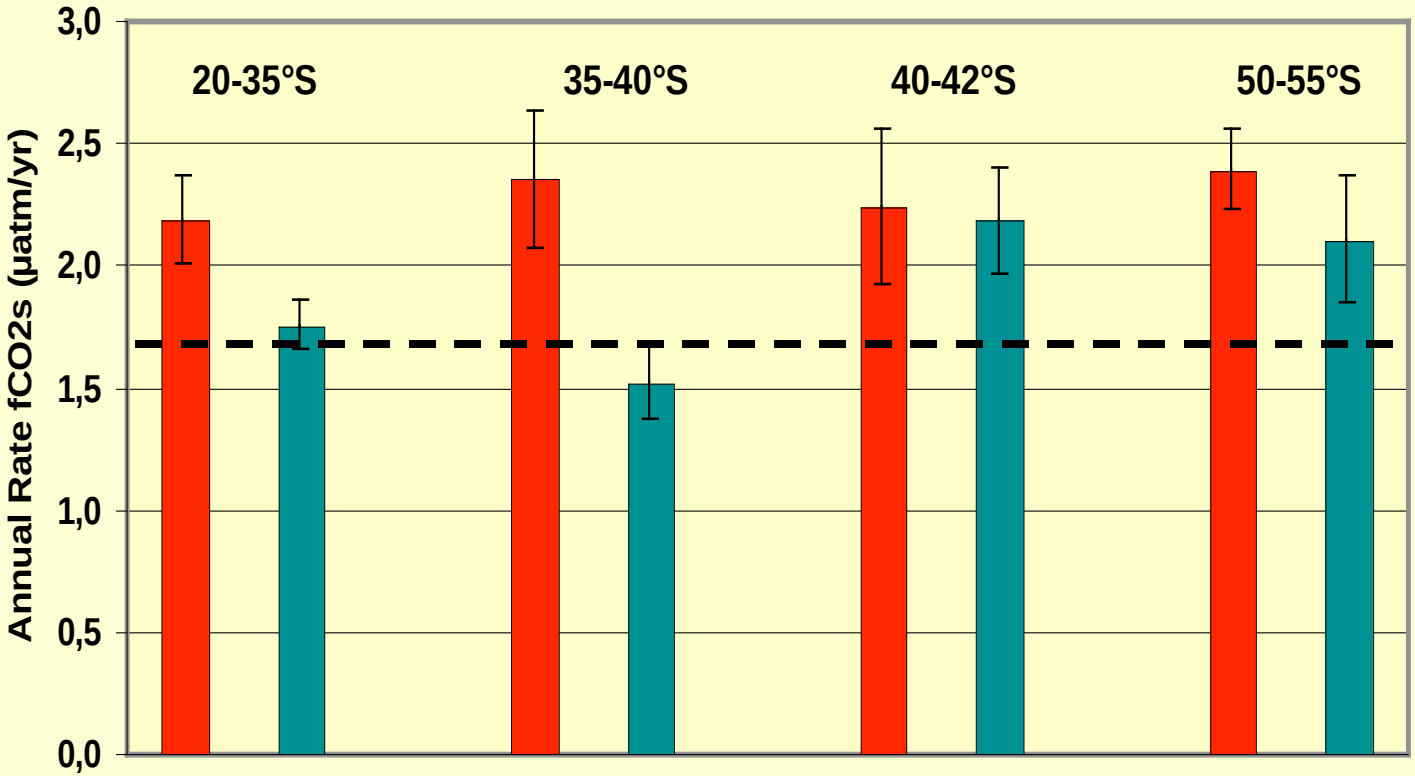


50-55°S



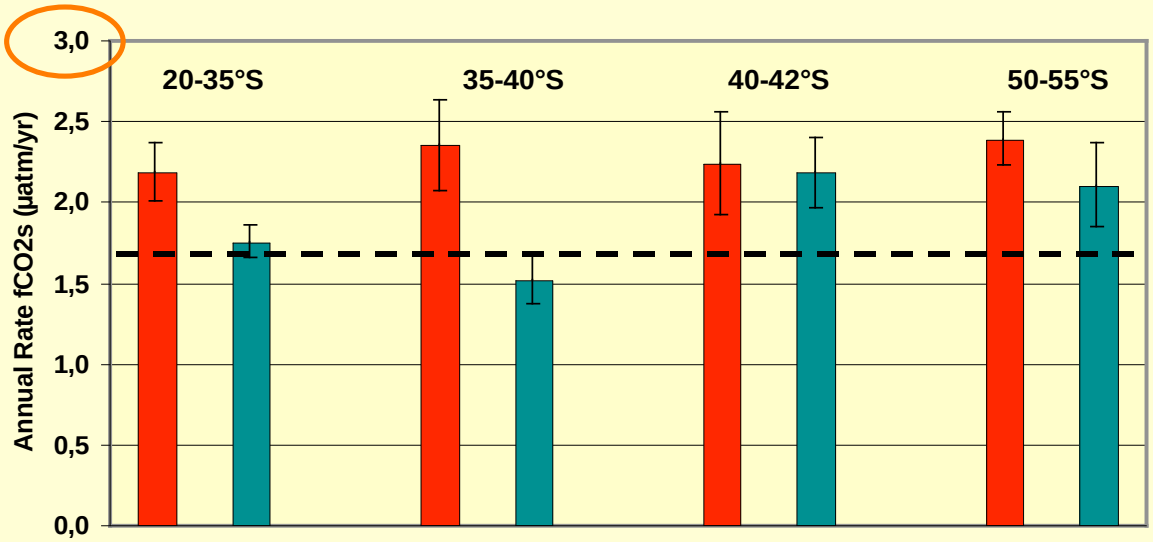
fCO2 always increases

Overview: Austral summer and winter ocean fCO2 trends (µatm/yr)
In four regions in the South-Western Indian Ocean

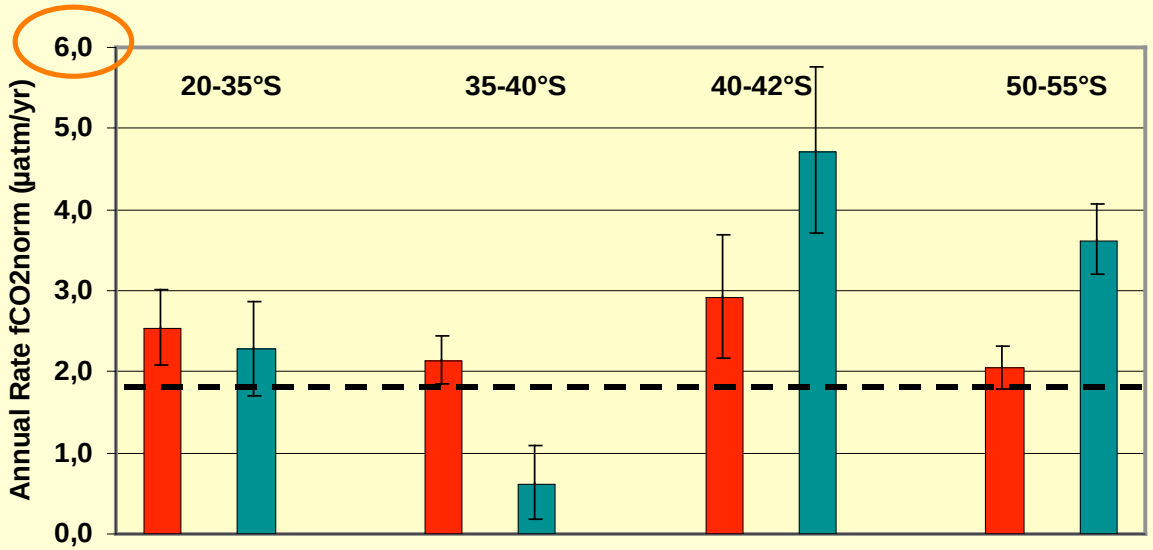


Almost always above the atmospheric CO2 rate
Decreased Sink & Increased Source

Normalising to T -> Mechanisms driving these trends



Shipbased fCO_2



Normalized fCO_2

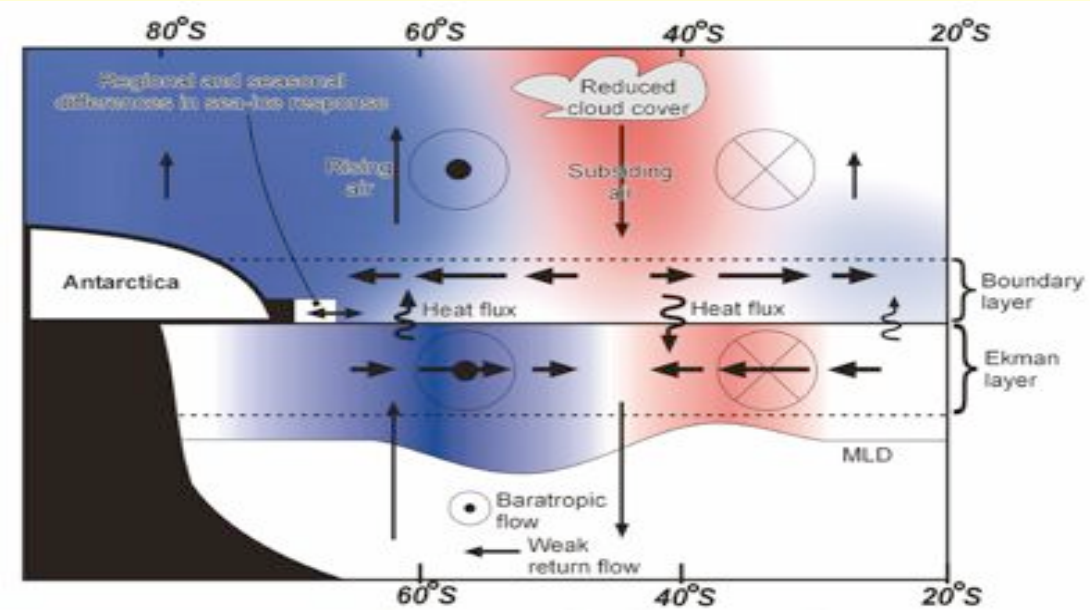
Contrasting results
in winter,
north and
south of 40°S

Less DIC ? More DIC ?

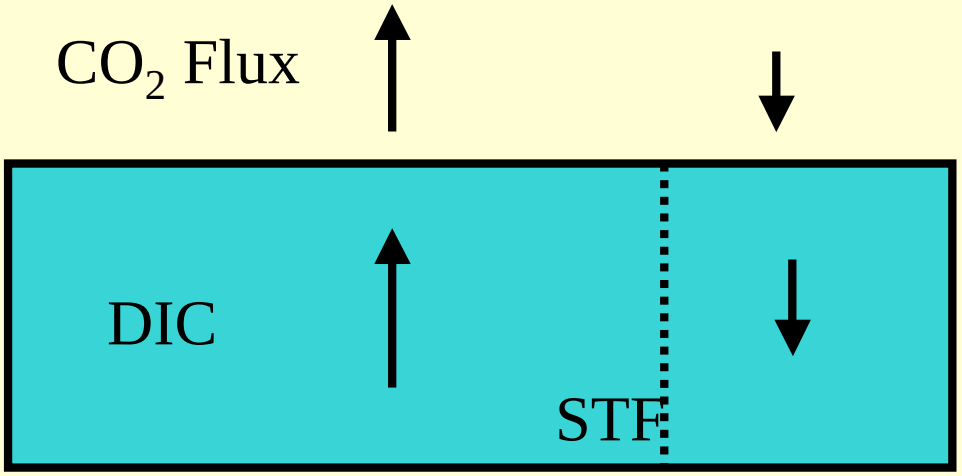
Large Scale Climate Forcing? :

Physical

Carbon Cycle

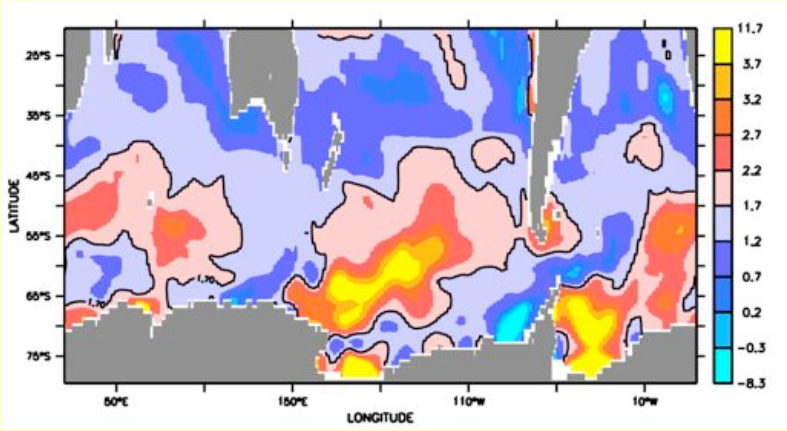


Sen Gupta and England, 2006

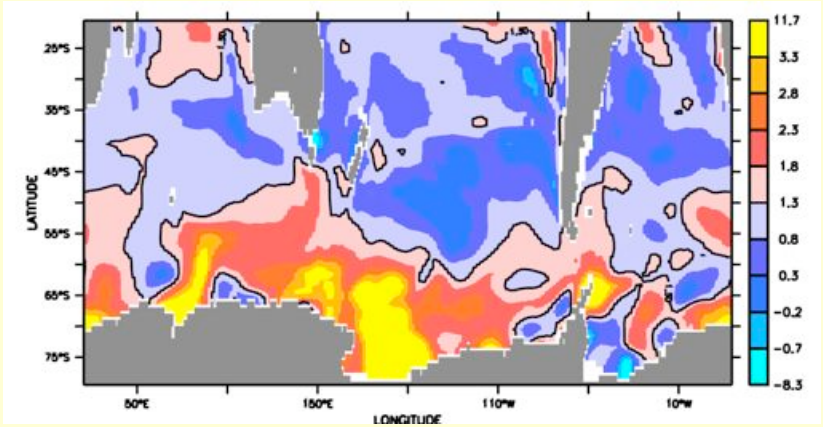


Lenton and Matear, 2007

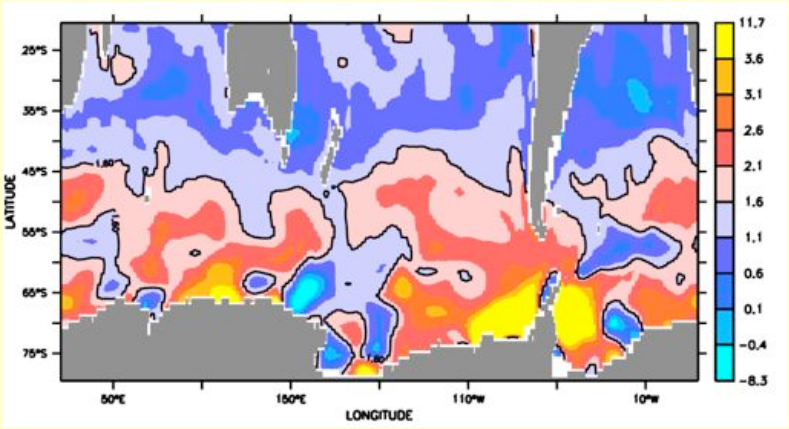
Decadal evolution modelled pCO_2



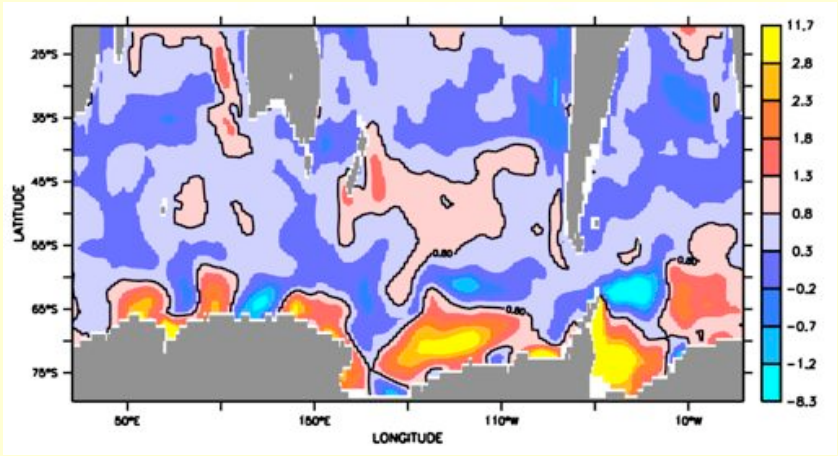
1990-2001



1970s



1980s



1960s

Lenton and Metzl, 2007

Conclusions

- Decadal CO_2 trends based on observations (1991-2007)
- Ocean pCO_2 increases faster than in the atmosphere, but never far
- Normalised pCO_2 (T) highlights;
  - Large contrast north and south of 40°S
  - likely linked to change of DIC vertical import (SAM)
  - Consistent with observed atmospheric response (LeQuéré et al 2007)
- Oceanic pCO_2 tells us about the evolution of the system, particularly DIC

, but evolution is complex temporal and spatially

- Future work
  - Comparing trends in several S.O. regions
  - Analysing observed DIC trends
  - Trends related to natural and anthropogenic carbon

References

Le Quéré, C. et al. (2007), Saturation of the Southern Ocean CO_2 Sink Due to Recent Climate Change, *Science*, 316(5832),1735 - 1738, DOI: 10.1126/science.1136188

Lenton, A., and R. J. Matear (2007), The role of the Southern Annular Mode (SAM) in Southern Ocean CO_2 uptake, *Global Biogeochemical Cycles*, *21*, doi: 10:1029/2006GB002714.

Lenton, A. and N. Metzl (2007), Model/observation comparison: focus on interannual variability, Carboocean Annual Meeting, WG 5, Bremen, Germany

Sen Gupta, A. and M. England (2006), Coupled Ocean-Atmosphere-Ice Response to variations in the Southern Annular Mode . *Journal of Climate*, 19(18), 4457–4486.